Unpacking Scientific Explanation

Scientific Explanation
A written or oral response to a question about how or why a phenomenon occurs that is supported by evidence. Hypotheses are "plausible explanations for an observed phenomenon that can predict what will happen in a given situation." (NRC, 2012, p. 67).

Constructing explanations involves articulating a claim responding to a question about how or why a phenomenon occurs, describing or citing appropriate evidence supporting the claim, and providing reasoning that describes how or why the evidence supports the claim using appropriate scientific principles.

Intersections with other Practices

- Results of **data analysis** and output from **models** can be used as evidence for explanations or hypotheses
- **Investigations** can inform the construction of explanations
- **Scientific arguments** critique or defend the strength/validity of explanations

Components of the Practice

Component	Description	Evidence of high performance
Claim	**Articulate** a testable statement or conclusion that answers a question about how or why	Student makes a testable statement or conclusion that **correctly** answers a question about how or why in a way that is consistent with available evidence
Evidence	**Describe** or **provide** scientific data that support the claim Sources of data include (but are not limited to) student-conducted investigations, everyday observations, reading material, numerical data, and model outputs	Student describes or provides **appropriate** and **sufficient** scientific data that support the claim
Reasoning	**Describe** how or why the data support the claim using scientific ideas/principles	Student describes how or why the evidence support the claim using **appropriate** and **valid** scientific ideas/principles

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Unpacking Developing and Using Models

A scientific model is an abstract, simplified, representation of an object, phenomenon, or system of phenomena that makes its central features explicit and visible. Models can be used to communicate information about objects and phenomena and generate explanations and predictions. They include diagrams, physical replicas, mathematical representations, analogies, and computer simulations.

Developing models involves generating a representation having elements and relationships that communicate information about a target object, explain a target phenomenon, representing the correspondence between these elements and the real world, and specifying the limitations of the model. **Using models** involves applying a previously developed model to answering a scientific question and can include generating explanations based on the model.

Intersections with other practices

- Output from models can be used as evidence for **explanations** and **arguments**
- **Scientific arguments** critique or defend the quality or appropriateness of models
- Models are developed based on results of **data analysis**
- **Investigations** may inform the development of models or involve the use of models
- Models **communicate information** about objects to intended audiences

Components of the practice

Component	Description	Evidence of high performance
Model elements	**Specify/identify** elements of the model (and their attributes)	Student specifies/Identifies **only the appropriate and necessary** elements (and their attributes) in the model **needed to explain the target phenomenon or communicate the desired information**
Relationships among elements	**Represent/describe** the relationships or interactions among model elements	Student represents/describes **only the appropriate and necessary** relationships and/or interactions among model elements **needed to explain the target phenomenon or communicate the desired information**
Correspondence	**Represent/describe** the correspondence between the model and the target phenomenon	Student **correctly** represents/describes the correspondence between model elements/relationships and the real world object or phenomenon
Limitations	**Specify/identify** the limitations of the model	Student specifies/identifies **the appropriate** limitations of the model **with respect to explaining the target phenomenon or communicating the desired information**
Explanation/ prediction	**Explain or predict** phenomena using the model	Student constructs **a correct and complete** explanation or prediction of the phenomenon using the model

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Using Mathematics and Computational Thinking

Mathematics and computation thinking are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks, such as constructing simulations, statistically analyzing data, and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable predictions of the behavior of physical systems, along with the testing of such predictions. Moreover, statistical techniques are invaluable for assessing the significance of patterns or correlations.

Using mathematics and computational thinking involves expressing relationships in mathematical and algorithmic forms, using computer programs for measurement and data representation, and expressing and applying quantitative relationships to analyze data.

Intersections with other practices

- Output from mathematical models can be used as evidence for **explanations** and **arguments**
- **Scientific arguments** critique or defend the quality or appropriateness of simulations by comparing them to real-world data
- Mathematical modeling and statistical analysis are forms of **data analysis**
- Data from **investigations** can be collected using mathematical measurement tools and analyzed for quantitative relationships

Components of the practice

Component	Description	Evidence of high performance
Representation	**Use measurement tools and construct** different kinds of mathematical representations of relationships	Student records measurements as part of an investigation and develops a graphical representation, equation, or algorithm that corresponds to a verbal description or visual depiction of a phenomenon.
Modeling	Use **mathematics to model** phenomena to make predictions about the behavior of a physical system	Student develops an equation or algorithm that explains a pattern in data and uses a mathematical formula to make a prediction about the state of a system in the future, given data from the past.
Analysis	**Recognize, express, and apply** quantitative relationships to analyze data and use **statistics** to assess the significance of patterns in data	Student constructs a scientific explanation for the results of a simulation, uses a scientific theory to explain the rules of a simulation, and justifies whether the results of a particular simulation make sense, by comparing to real-world data.

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